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Lacerta OB1 Revisited

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ABSTRACT. This investigation utilizes precise $uvby\beta$ photometry and the recently recalculated *Hipparcos* data to provide an improved homogeneous distance scale for the apparent groups of young stars in Lacerta. All existing $uvby\beta$ photometry for stars earlier than A0-type in a $20^\circ \times 20^\circ$ field centered at $l = 100^\circ$, $b = -15^\circ$ is collated and the individual stellar distances and color excesses are obtained. The association Lac OB1 is reliably identified as a very compact young group of 12 bright stars at an average distance of $520 \pm 20(\text{s.e.})$ pc. The available radial velocity and proper motion measurements strongly support the impression that the group is real. The stars in the northeast part of Lacerta seem not to represent a physical group, but rather a layer of field stars spread between 140 and 400 pc and extending farther than that toward $l \sim 104^\circ$. An estimate of $678 \pm 50(\text{s.e.})$ pc of the distance to the open cluster NGC 7243 is obtained based on the brightest cluster members. The calculated distances are based on a well-tested procedure, and thus represent a clarification over the range of distance existing in the literature for the bright stars in the Lacerta field. Although a better agreement is now evident between the photometric distances and the recalculated *Hipparcos* parallaxes in comparison to the original *Hipparcos* data, discrepancies still exist for this particular field.

1. INTRODUCTION

The detailed study of the high-mass star formation processes in the solar neighborhood provides unique inputs for the overall understanding of the physics of star formation on larger galactic and extragalactic scales. In this context, the critical role of reliable knowledge of the properties of the nearby young stellar populace is well known.

Despite the extensive efforts of clarifying the basic structural parameters and inferring a homogeneous distance scale for the nearby young stellar groups, discrepancies yet remain in the published studies. The controversial results about distance and membership are often due to the use of different photometric systems and incomplete samples. Most importantly, statistically significant differences between the original *Hipparcos* (ESA 1997) parallaxes and traditional photometric, spectroscopic, and interferometric results have been reported in the literature not only for small-scale fields like selected nearby open clusters, but also on larger scales for some of the Galactic OB associations (see Kaltcheva & Makarov 2007 and the references therein). It has been shown, however, that the discrepancy between *Hipparcos* and ground-based parallaxes both for nearby clusters and OB associations can be resolved by recomputing the *Hipparcos* astrometric solutions with an improved algorithm diminishing correlated errors in the altitude parameters (Makarov 2002). In this context, the recently revised *Hipparcos* catalog (van Leeuwen 2007) also should be in position to provide a comprehensive astrometric census of the nearby OB groups.

For the nearby Lac OB1 association, the discrepancy between the photometry-derived distances and the original *Hipparcos* astrometry is reported to be the largest (de Zeeuw et al. 1999). This paper utilizes the $uvby\beta$ data existing in the literature for the early-type stars in the Lacerta field to provide precise photometry-derived stellar distances to the main apparent groupings in the field. The obtained distances are discussed in the light of the revised *Hipparcos* parallaxes and other distance estimates already existing in the literature.

2. THE FIELD OF LAC OB1

As mentioned by Blaauw & Morgan (1953), the OB association in Lacerta can be easily recognized on a plot of the O and B type stars in the Henry Draper Catalogue. The conspicuous clustering of early-type stars near 10 Lacertae initially gained attention because of the expanding motion of its members. Since then, many attempts have been made to obtain reliable estimates of distances and color excesses of the stars that belong to the aggregate (Harris 1955). Based on possible systematic differences in age and stellar content, Blaauw (1958) subdivided the association into two subgroups, a younger compact group (Ib) around 10 Lac, and a larger group of dispersed, older, more-evolved stars spreading to the northeast (Ia). Coyne et al. (1969) determined spectral classes and photographic magnitudes of 3621 stars and found an excess of early main-sequence A-type stars in the concentrated region of the association as compared to the disperse region. Lesh (1968, 1969) obtained spectral types of the brightest members of the subgroups and found that the concentrated and dispersed regions have mean distance moduli differing by 1 mag. Crawford (1961) published Hβ photometry of 69 stars in the field and confirmed the finding of Blaauw (1958) that the stars lying in the dispersed region of the association are systematically older than those in the concentrated part near 10 Lac. Based on their $uvby\beta$ photometry, Crawford & Warren (1976) showed that the more dispersed subgroup has a larger average color excess and a larger dispersion in both color excess and distance modulus for its members. In their new list of the galactic OB associations, Melnik & Efremov (1995) did not confirm Lac OB1 as a real group. Using the original *Hipparcos* data, de Zeeuw et al. (1999) identified 96 *Hipparcos* members of the Lacerta moving group at a distance significantly smaller than the previous photometric estimates. Table 1 summarizes the distance available at present to the Lacerta subgroups and the methods used for these estimates.

The field of Lacerta offers an unique opportunity to study the influence of massive stars on the interstellar matter. The distribution and kinematics of neutral hydrogen has been studied by Cappa de Nicolau & Olano (1990), who found an H I deficiency centered in the Ib subgroup. The HII region S 126 (Sharpless 1959) is located within this subgroup as well. The large, comet-like dust and gas complex known as LBN 437 (Olano et al.1994) lies at the edge of the Ib subgroup, which may be responsible for its cometary morphology. As mentioned by these authors, since subgroups Ia and Ib are the only young stellar structures associated with these features of interstellar matter, a reliable reconstruction of the star-forming history of the field should be possible, once the spatial distribution of the young stars has been reliably determined. A comprehensive review of the interstellar matter studies in Lacerta was recently presented by Chen & Lee (2008).

3. THE SAMPLE

The field considered in this article extends between 90° and 110° galactic longitude and $-25°$ and $-5°$ galactic latitude. This is the field studied by de Zeeuw et al. (1999) based on the original *Hipparcos* data. All available $uvby\beta$ photometry of stars within this coordinate range was extracted from the $uvby\beta$ catalog of Hauck & Mermilliod (1998). Then, based on the $[c_1]$ versus $[m_1]$ diagram, only stars earlier than spectral type A0 were left in the sample. The final sample contains 55 stars with complete photometry and is listed in Table 2.

Figure 1 presents the sample stars of different subgroups identified so far in the Lacerta field plotted in Galactic coordinates. In the figures, the various subgroups are distinguished by different symbols, as identified in the caption of Figure 1. The group marked with open symbols, which is located toward 10 Lac, is usually referred to as Lac OB1 association (these stars all belong to the Blaauw's group Ib). The stars located toward the northeast part of the field studied, where the group Ia of Blaauw has been identified, are shown with filled symbols. Note that some of the stars originally included in the groups Ia and Ib either do not have $uvby\beta$ data available currently, or their $uvby\beta$ photometry implies spectral types A0 or later, and they are thus excluded from this study. In order to indicate the overlap between our sample and the Ia and Ib groups, all stars previously included in them are shown with open squares in Figure 1.

4. CALCULATION OF INTERSTELLAR ABSORPTION AND DISTANCES

When inferring physical parameters from the photometry, the luminosity classification is an important issue because different calibrations are used for different luminosity types. The luminosity classifications available in the SIMBAD database were adopted, but a careful investigation of the stellar content of the sample based on the classification $[c_1]$ versus $[m_1]$ diagram (Strömgren 1966, Fig. 2a) was also performed. In all ambiguous cases the individual sources of the spectral classifications were considered.

The procedure applied here to derive the color excesses and stellar distances is described in detail in Kaltcheva & Hilditch (2000, hereafter KH). The color excesses for LC III, IV and V are obtained via Crawford's (1978) calibration and the calibration by Kilkenny & Whittet (1985) is used for LC II, Ib, Iab, and Ia. The c_1 versus $b-y$ diagram in Figure 2b implies that the majority of the stars are marginally reddened main-sequence

TABLE 1

SUMMARY OF THE MOST RECENT DISTANCE DETERMINATIONS TO THE LACERTA SUBGROUPS

Sources	Distance modulus/Distance	Subgroup	Method
Blaauw 1958	8.6 ± 0.2 (524 pc)	Ia+Ib	Comparison to Sco-Cen
Crawford 1961	8.9 (603 pc)	Ia+Ib	M_V (β)
Lesh 1968	8.29 (455 pc)	Ia+Ib	MK types
Lesh 1969	7.83 ± 0.14 (368 pc)	Ib	MK types
Lesh 1969	8.9 ± 0.14 (603 pc)	Ia	MK types
Crawford & Warren 1976	8.4 ± 0.3 (479 pc)	Ib	M_V (β)
Crawford & Warren 1976	8.1 ± 0.5 (417 pc)	Ia	M_V (β)
de Zeeuw et al. 1999	368 ± 17	All *Hipparcos* members	*Hipparcos* parallaxes
de Zeeuw et al. 1999	358 ± 22	Ib	*Hipparcos* parallaxes

TABLE 2

THE SAMPLE ORGANIZED ACCORDING TO THE SUBGROUPS IDENTIFIED IN FIG. 1

HD/BD	MK/Remarks	V	$b-y$	m_1	c_1	β	$(b-y)_0$	c_0	m_0	$E(b-y)$	V_0	M_V	DM	r (pc)	l°	b°
Group Ib																
212978	B2 IV-V	6.17	−0.05	0.07	0.18	2.65	−0.10	0.17	0.09	0.05	5.96	−2.13	8.09	414	95.04	−15.14
213801	B9V	8.17	−0.01	0.10	0.62	2.75	−0.06	0.61	0.12	0.05	7.96	−0.32	8.28	452	95.92	−15.95
214022	B6V	8.52	0.01	0.08	0.45	2.75	−0.07	0.44	0.10	0.08	8.17	−0.30	8.47	494	96.79	−15.10
214167	B2V	6.47	−0.06	0.08	0.11	2.65	−0.11	0.10	0.10	0.05	6.26	−2.15	8.41	482	96.37	−16.15
214168A	B1 Ve	5.73	−0.05	0.06	0.02	2.61	−0.12	0.01	0.08	0.07	5.43	−3.34	8.77	567	96.37	−16.15
214243	B3V	8.30	−0.04	0.11	0.30	2.71	−0.09	0.29	0.12	0.05	8.11	−0.89	9.00	630	96.69	−15.80
214263	B1.5 V	6.84	−0.05	0.08	0.14	2.65	−0.10	0.13	0.10	0.05	6.62	−2.11	8.73	557	95.49	−17.73
214432	B2.5 V	7.59	−0.05	0.10	0.23	2.67	−0.09	0.22	0.12	0.04	7.40	−1.59	8.99	628	96.55	−16.47
214652	B1.5 V SB1	6.83	−0.05	0.08	0.15	2.66	−0.10	0.14	0.10	0.06	6.58	−1.97	8.55	513	95.72	−18.40
214680A	O9 V, 10Lac	4.89	−0.07	0.04	−0.11	2.59	−0.13	−0.12	0.06	0.06	4.63	−4.64	9.27	715	96.65	−16.98
214993	B1 III	5.26	−0.03	0.05	0.05	2.61	−0.11	0.04	0.08	0.08	4.92	−3.26	8.19	434	97.65	−16.18
215191	B1.5 V	6.43	−0.03	0.07	0.08	2.63	−0.11	0.07	0.10	0.08	6.07	−2.66	8.73	558	96.64	−18.42
215211	B7 V	8.68	−0.02	0.10	0.52	2.76	−0.07	0.51	0.11	0.05	8.47	−0.06	8.53	509	97.17	−17.60
Group Filled Symbols																
209932	A0 V	6.44	0.00	0.13	0.92	2.84	−0.03	0.92	0.14	0.02	6.34	0.75	5.60	132	94.77	−8.51
212222	B5 V	6.40	−0.02	0.09	0.44	2.72	−0.08	0.43	0.11	0.05	6.17	−0.74	6.91	241	95.41	−12.66
212593	B9 Iab	4.56	0.12	0.03	0.61	2.61	−0.06	0.58	0.09	0.18	3.80	−4.42	8.22	441	99.90	−6.71
213420	B1.5 IV	4.53	−0.01	0.06	0.19	2.63	−0.10	0.17	0.09	0.09	4.13	−2.62	6.75	224	97.36	−12.64
214240	B3 V	6.29	0.01	0.07	0.40	2.68	−0.08	0.38	0.10	0.08	5.93	−1.39	7.31	290	101.79	−7.15
214444	A	8.73	0.05	0.06	0.46	2.65	−0.07	0.43	0.11	0.13	8.19	−2.16	10.35	1176	102.45	−6.44
216523	B8 V	6.46	0.00	0.11	0.60	2.76	−0.06	0.59	0.13	0.06	6.22	−0.10	6.32	184	104.36	−8.13
217262	A0	8.25	0.11	0.06	0.33	2.69	−0.09	0.29	0.12	0.20	7.39	−1.27	8.65	537	103.46	−12.24
217945	A0	8.95	0.06	0.06	0.47	2.69	−0.07	0.45	0.11	0.13	8.38	−1.20	9.57	821	104.25	−12.60
218042	A0	7.78	−0.02	0.13	0.84	2.82	−0.04	0.83	0.14	0.02	7.71	0.57	7.13	267	102.18	−17.24
218407	B2.5 V	6.66	0.01	0.07	0.19	2.64	−0.10	0.17	0.10	0.11	6.19	−2.28	8.46	492	104.71	−13.09
219927	B8 III	6.33	−0.01	0.10	0.64	2.72	−0.06	0.63	0.11	0.05	6.13	−0.80	6.93	243	102.31	−24.37
220575	B8 III	6.72	0.05	0.07	0.75	2.72	−0.05	0.73	0.11	0.10	6.30	−0.96	7.26	283	105.80	−18.85
222173	B8 V	4.29	−0.03	0.10	0.78	2.73	−0.04	0.78	0.10	0.01	4.25	−0.87	5.12	106	109.03	−17.62
222439	B9 IVn	4.15	−0.04	0.13	0.83	2.83	−0.04	0.83	0.13	0.00	4.15	0.68	3.47	49	109.76	−16.71
209961	B2 V, var	6.30	0.01	0.06	0.19	2.64	−0.10	0.17	0.09	0.10	5.85	−2.30	8.15	426	96.64	−6.00
212120	B6 V, A	4.57	−0.03	0.10	0.48	2.69	−0.07	0.47	0.11	0.04	4.40	−1.19	5.60	132	97.79	−8.86
217050	B3 IVpe, var	5.42	−0.01	0.06	0.47	2.50	−0.07	0.46	0.08	0.07	5.14	−0.62:	5.76:	142:	104.22	−9.99
219749	B9 p, var	6.49	−0.01	0.12	0.76	2.77	−0.04	0.76	0.13	0.03	6.34	−0.14	6.49	198	106.25	−14.33
Group Asterisks																
215592	A0	7.86	0.07	0.08	0.78	2.79	−0.04	0.75	0.12	0.11	7.37	0.17	7.20	276	99.20	−15.12
216200	B4 IV, var	5.93	0.10	0.04	0.33	2.63	−0.09	0.30	0.10	0.19	5.13	−2.39	7.52	319	100.04	−15.47
216369	A0	7.08	0.03	0.11	0.81	2.80	−0.04	0.80	0.13	0.06	6.81	0.32	6.49	199	99.98	−16.17
216538	B7 III	6.34	−0.02	0.09	0.56	2.71	−0.06	0.55	0.11	0.05	6.13	−0.94	7.08	260	99.67	−17.30
216831	B7 III	5.72	0.00	0.09	0.63	2.71	−0.06	0.62	0.11	0.05	5.49	−0.86	6.35	186	98.28	−20.92
217101	B2 IV−V	6.18	−0.05	0.08	0.11	2.66	−0.11	0.10	0.10	0.05	5.96	−1.97	7.92	384	100.07	−18.46
217543	B2 V	6.53	−0.03	0.08	0.24	2.65	−0.09	0.23	0.10	0.06	6.27	−1.99	8.26	448	100.38	−19.28
38+4883	B9V	9.49	0.00	0.12	0.75	2.80	−0.04	0.74	0.14	0.04	9.31	0.39	8.92	608	98.94	−18.09

TABLE 2 (*Continued*)

HD/BD	MK/Remarks	V	$b-y$	m_1	c_1	β	$(b-y)_0$	c_0	m_0	$E(b-y)$	V_0	M_V	DM	r (pc)	l°	b°
NGC 7243 Crosses ……																
7243 358 …..	B8 V	9.40	0.11	0.06	0.58	2.73	–0.06	0.54	0.12	0.17	8.66	–0.48	9.14	674	98.84	–5.53
7243 370 …..	A0 Vp	9.95	0.05	0.09	0.53	2.74	–0.07	0.51	0.13	0.12	9.44	–0.35	9.78	905	98.96	–5.52
7243 377 …..	B9 V	9.25	0.09	0.07	0.50	2.72	–0.07	0.47	0.12	0.16	8.58	–0.73	9.31	727	98.97	–5.59
7243 380 …..	B8 III	9.28	0.09	0.07	0.63	2.75	–0.06	0.60	0.12	0.14	8.66	–0.27	8.93	611	99.00	–5.56
7243 475 …..	B5 III	8.47	0.12	0.05	0.62	2.71	–0.06	0.59	0.11	0.18	7.70	–0.98	8.68	546	98.75	–5.48
7243 480 …..	B7 IV	8.73	0.10	0.07	0.59	2.73	–0.06	0.56	0.13	0.16	8.04	–0.49	8.52	507	98.78	–5.52
7243 482 …..	B8	9.09	0.11	0.07	0.56	2.74	–0.07	0.53	0.13	0.18	8.33	–0.40	8.73	558	98.77	–5.59
7243 490 …..	B7 III	10.13	0.10	0.08	0.54	2.74	–0.07	0.51	0.14	0.16	9.43	–0.40	9.83	925	98.79	–5.65
7243 362 …..	B9 V	9.30	0.13	0.05	0.54	2.73	–0.07	0.51	0.12	0.19	8.47	–0.60	9.06	649	98.85	–5.54
NGC 7243 Plus signs ……																
7243 368 …..	B9 V	10.91	0.12	0.09	0.91	2.81	–0.03	0.88	0.14	0.15	10.28	0.36	9.92	965	98.93	–5.54
7243 386 …..	B9 V	10.34	0.11	0.09	0.80	2.81	–0.04	0.78	0.14	0.15	9.69	0.41	9.28	718	99.03	–5.57
7243 392 …..	A0 V	10.90	0.10	0.09	0.93	2.84	–0.03	0.91	0.13	0.13	10.35	0.70	9.65	851	99.07	–5.61
7243 471 …..	A0 V	10.82	0.15	0.07	0.87	2.80	–0.04	0.84	0.13	0.18	10.04	0.26	9.78	902	98.71	–5.48
7243 496 …..	A0 V	10.43	0.13	0.06	0.82	2.76	–0.04	0.79	0.11	0.17	9.71	–0.21	9.92	964	98.84	–5.62
7243 510 …..	A0 V	10.59	0.15	0.08	0.84	2.83	–0.04	0.80	0.14	0.19	9.76	0.61	9.15	676	98.93	–5.60

NOTE.—Stellar identifications, followed by spectral type, *uvby*β photometric data, dereddened photometry, color excess, dereddened visual magnitude, calculated absolute magnitude, distance modulus, distance, and Galactic coordinates.

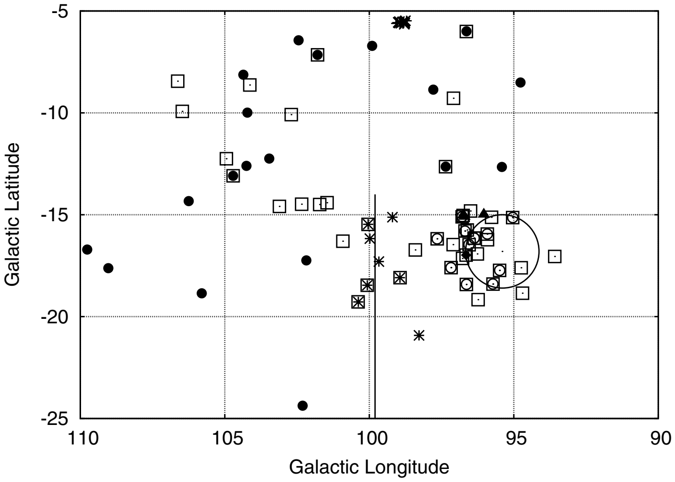

FIG. 1.—The stars in the field of Lacerta referred to different subgroups plotted in Galactic coordinates. *Asterisks:* the group at $l \sim 100°$ and b between $-15°$ and $-20°$; *open symbols:* stars toward $l \sim 96°$ and b between $-15°$ and $-19°$; *x symbols:* stars at $l = 98.5°$, $b = -6°$ (NGC 7243) with $V_0 = 9$ mag and brighter; *plus symbols:* NGC 7243 stars fainter than 9 mag; filled symbols: stars located at the northeast part of the field. *Open squares* are used to mark all stars originally included in the subgroups Ia and Ib and the line near $l = 100°$ is used to visualize this separation. The location of 10 Lac is shown with *filled diamond*. The large circle delimits the HII region S 126. The two *filled triangles* mark the locations of the molecular condensations identified in the LBN 437 complex (Olano et al. 1994).

stars (in agreement with the MK types) with c_1 values within the limits of the intrinsic color calibrations described. Luminosity Class V was adopted for the stars without LC available in SIMBAD. On the photometric diagrams (Fig. 2) they all appear close to the MS, and the calibration of Crawford (1978) was used to calculate the color excess. We used $R = 3.2$ and $E(B-V) = E(b-y)/0.74$ to obtain V_0. The calibration by Balona & Shobbrook (1984) is utilized for all stars to derive the M_V values. Since we are dealing with early spectral types, the presence of emission lines in the stellar spectra is the largest source of error in the calculated absolute magnitudes. The Hβ versus c_0 diagram (Fig. 2c), however, reveals that very few stars of the sample deviate from the main sequence and could have photometry affected by emission. For only one star (HD 217050, B3IVpe) a Hβ value calculated from c_0 was used instead of the observed Hβ value, which falls outside the limits of the M_V calibration (cf. Balona 1994 and KH for details). This star clearly shows emission in the Hβ index. The rest of the stars closely follow the MS on the c_0 versus Hβ diagram, except HD 212593, which is of LC Iab.

The photometric data and the derived stellar parameters are summarized in Table 2, which includes the stellar identifications, followed by the MK type and $uvby\beta$ photometric data, color excess and dereddened photometry, calculated absolute magnitude, and distance. Note that some of the stars in Table 2 have MK type A0. However, photometrically they appear earlier than A0-type and behave as late B-stars on all photometric diagrams. Since the photometric $uvby\beta$ classification is very reliable for the $B-G$ spectral range (Strömgren 1966), these stars were left in the sample and treated as B-type stars. The expected uncertainties in M_V are on the order of ±0.3 mag for LC III-V

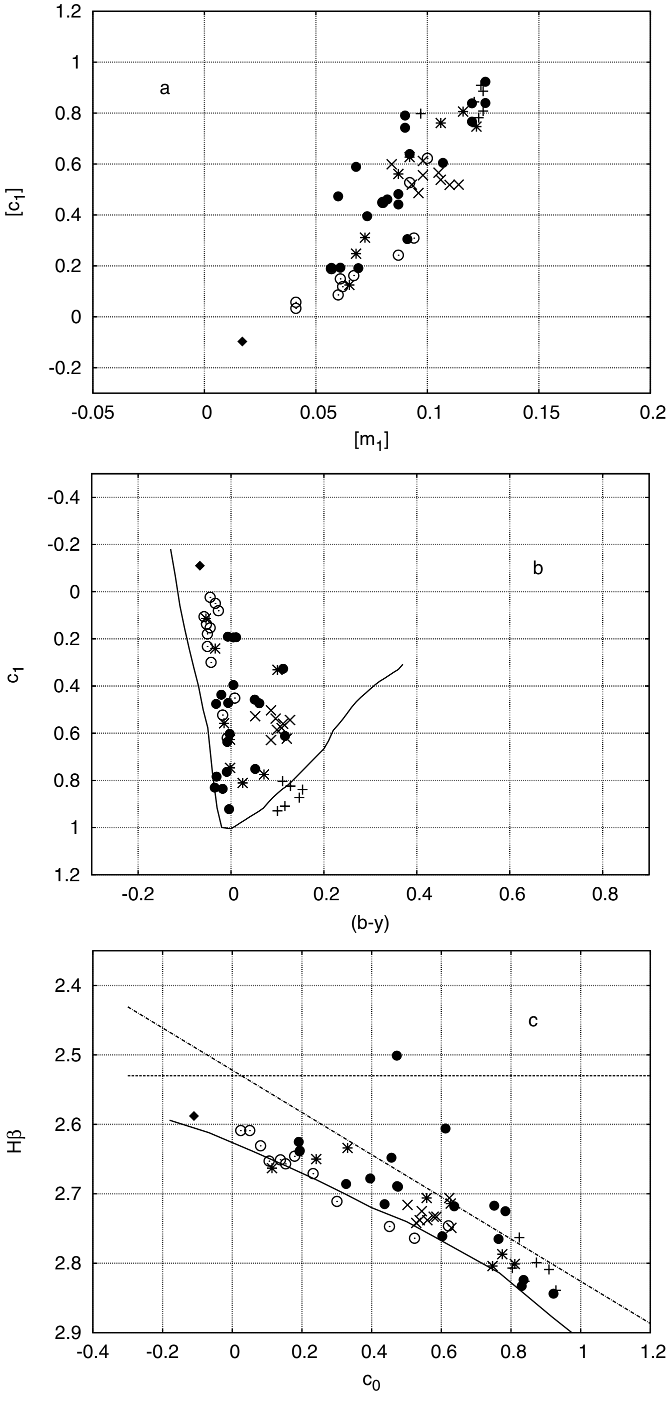

FIG. 2.—The photometric diagrams $[c_1]$ vs. $[m_1]$, c_1 vs. $b-y$ and Hβ vs. c_0 for the sample stars. The symbols are the same as in Fig. 1, but the open squares indicating the Blaauw's subgroups are omitted.

and ± 0.5 mag for supergiants (Balona & Shobbrook 1984). An uncertainty of ± 0.3 mag in M_V propagates to an asymmetric uncertainty of -13% to $+15\%$ in the derived distances, and uncertainties of ± 0.5 mag result in -21% to $+26\%$ uncertainties. Since only one star in the sample is more luminous than LC III, the overall error in the estimated distances should be considered to be -13% to $+15\%$ of the calculated values.

5. PHOTOMETRY-DERIVED RESULTS

Based on the photometry-derived stellar parameters, the stellar content, distribution of the interstellar absorption, and stellar distribution in the studied field are analyzed in order to reveal spatially coherent groups and layers. Figure 3 presents the diagrams distance r versus Galactic longitude l, color excess $E(b-y)$ versus l and $E(b-y)$ versus r. The photometric V_0 versus $(b-y)_0$ and M_V versus $(b-y)_0$ diagrams are shown in Figure 4.

A marginally reddened (mean $E(b-y) = 0.059 \pm 0.015$ mag) compact group of 12 stars (open symbols) located at 520 ± 20(s.e.) pc is found at average coordinates $l = 96.4°$, $b = -16.6°$. The stars belong to the Blaauw's subgroup Ib, often identified with the Lac OB1 association, and are listed at the beginning of Table 2. On both diagrams in Figure 4 they form a smooth main sequence. These are all arguments indicating that this is a real group with the characteristics of an OB association—Lac OB1. The distance to Lac OB1 obtained here is larger than the estimates found in the literature for the Blaauw's subgroup Ib (Table 1). However, the previous estimates are based to a large extent on preliminary distance calibrations and broadband photometry, while the one obtained here is based on a well-tested procedure (cf. Kaltcheva & Makarov, 2007). For example, note that the distance of 479 pc (Crawford & Warren 1976) is based on a M_V (β) calibration that provides slightly systematically fainter M_V and thus slightly smaller distances (Kaltcheva & Knude 1998).

This group of 12 stars (we will refer to it as Lac OB1 hereafter) is located toward the O9V star 10 Lac (HD 214680; the most massive star in the sample) at a photometric distance of 715^{+107}_{-92} pc. The errors in the photometric distance are calculated assuming an error of 0.3 in the M_V determination (Balona & Shobbrook 1984). Although there is agreement within the errors, the obtained photometric distance for 10 Lac (715 pc) is considerably larger than the estimate of 529^{+70}_{-50} pc based on the new *Hipparcos* parallax (van Leeuwen 2007). However, the agreement now is much better in comparison with the old *Hipparcos* estimate of 325^{+82}_{-55} pc. 10 Lac is a standard star for Hβ photometry (Crawford & Mander 1966), with more than 60 individual Hβ measurements and 13 measurements in $uvby$. The location of the star on the M_V versus $(b-y)_0$ and M_V versus c_0 diagram does not indicate any peculiarity due to emission (see Fabregat et al. 1996). Using the largest Hβ value, 2.597, reported in the literature (Fabregat et al. 1996) leads to the lowest possible photometric distance of 680 pc. Because of the numerous $uvby\beta$ measurements collected for this star and absence of emission on the photometric diagrams, the distance of 715 pc should be considered reliable. The $uvby\beta$ photometric distance in general should not be influenced by rotation, as

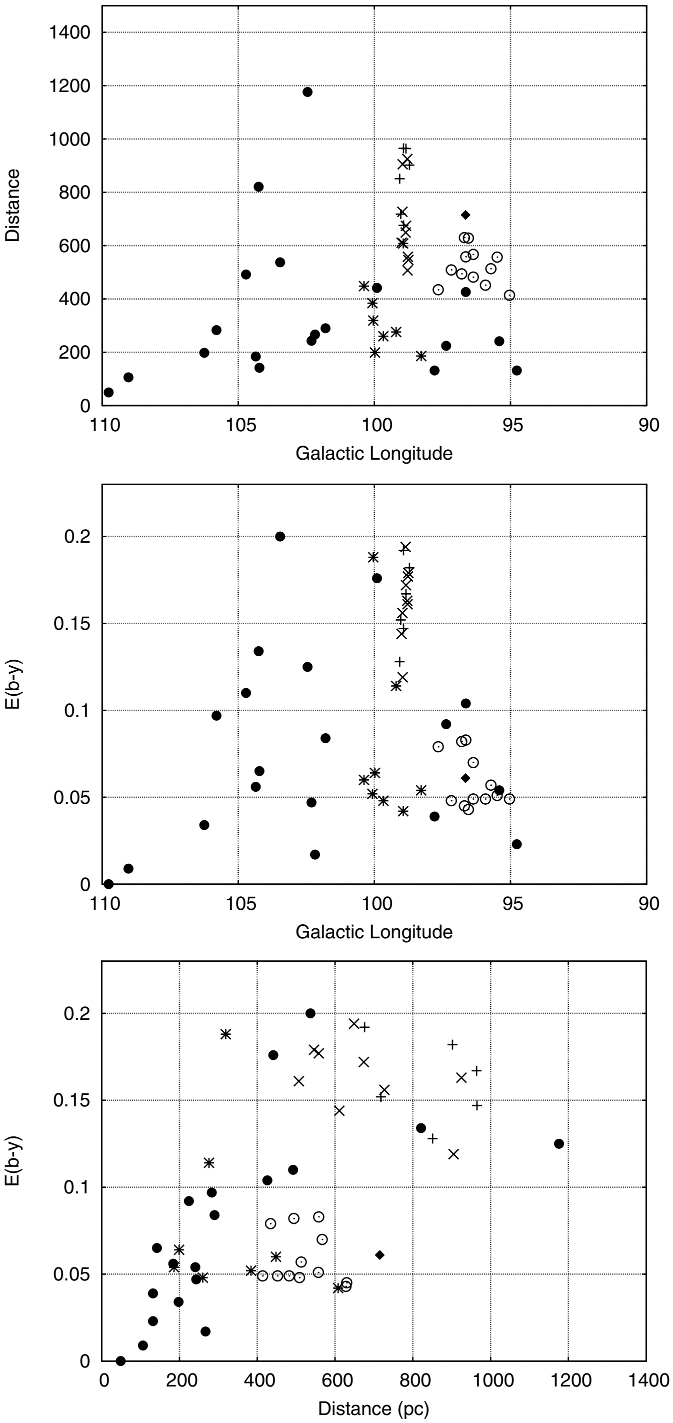

FIG. 3.—The diagrams distance vs. Galactic longitude, color excess vs. Galactic longitude, and color excess vs. distance for the sample stars. The symbols are the same as in Fig. 2.

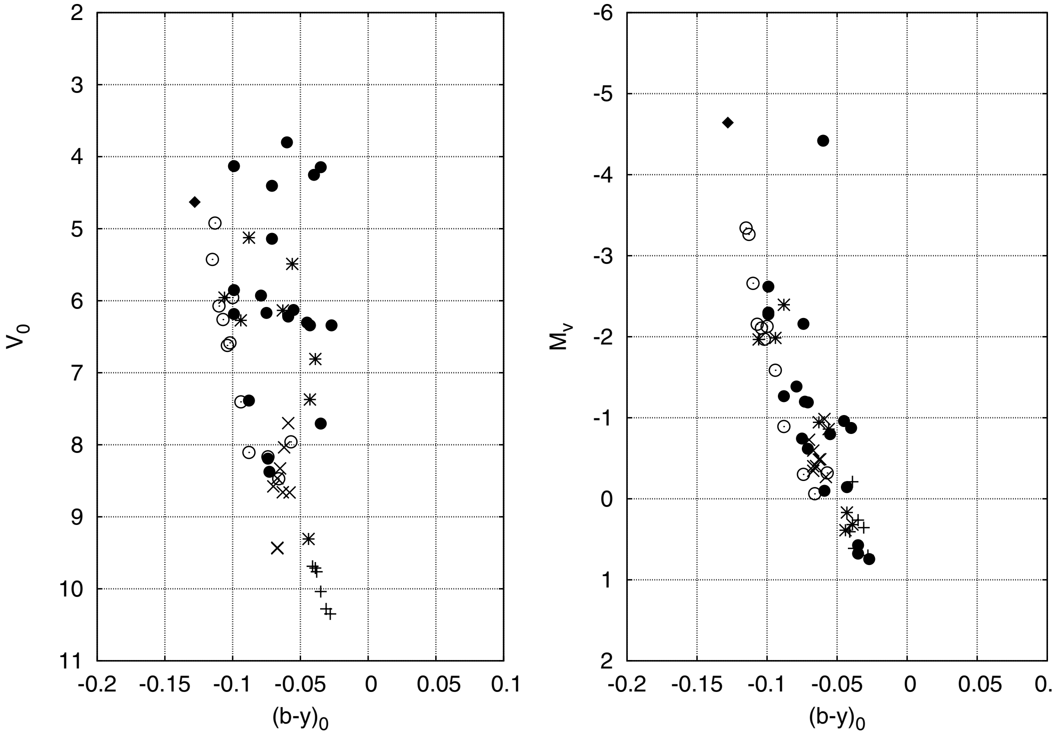

FIG. 4.—The diagrams V_0 vs. $(b-y)_0$ and M_V vs. $(b-y)_0$ for the sample stars. The symbols are the same as in Fig. 2.

shown in Kaltcheva & Knude (1998). It is difficult, however, to conclude whether Lac 10 is a member of Lac OB1 or not. Photometrically the star is significantly more distant than the Lac OB1 group.

OB associations may also be detected kinematically as their internal velocity dispersion is, in general, small. Nine of the 12 photometric members of Lac OB1 have radial velocity measurements of high quality (Wilson 1953). The measured velocities are in the range from -11 km s^{-1} to -19.5 km s^{-1}, with a median value of -15 ± 0.9 s.e. and standard deviation of 2.7 km s^{-1}, well within the radial velocity dispersion limit for an OB association (Mathieu 1986). Thus the available radial velocities support the existence of a Lac OB1 association. The radial velocity for 10 Lac is -9.7 km s^{-1}, suggesting that the star might indeed be a member of the association.

The subgroup of 8 stars marked with asterisks in the direction $l = 99.6°$, $b = -17.6°$ is located at an average distance of 335 ± 50(s.e.) pc and has average $E(b-y) = 0.078 \pm 0.050$ mag. The relatively large spread in distance and lack of well-defined sequence on the V_0 versus $(b-y)_0$ diagram suggest that these stars do not form a physical group. Their radial velocities cover a range between 6.5 and -18 km s^{-1}.

The stars of the dispersed group (filled symbols) at the northeast part of the field are mainly located between 142 and 420 pc. Toward $l = 104°$ there are, however, stars more distant and reddened in comparison to the rest of the subgroup. On the $E(b-y)$ versus r diagram (Fig. 3) an increase of the color excess with the distance is evident, typical for field stars. It is unlikely that they form a physical group. Figure 3 indicates similar properties of the absorption by the interstellar medium as in Figure 6n-301 in Neckel & Klare (1980), their extensive study of the Galactic dust distribution. The interstellar extinction A_V as represented by the field stars increases uniformly from 0 to 0.9 mag at 900 pc, and does not significantly fluctuate beyond this distance.

The open cluster NGC 7243 has been investigated by a number of authors. Based on proper motions, Jilinski et al. (2003) identified 211 cluster members down to $V = 15.5$ mag at a distance of 698^{+130}_{-109} pc and reddening $E(B-V) = 0.24$. Based on *uvby*β photometry of 18 members, Hill & Barnes (1971) obtained distance modulus of 9.4 ± 0.1 mag (759 pc). In our sample, 15 stars of NGC 7243 are included, with all of them, except 7243−362, found to have membership probability of 81% and higher (Jilinski et al. 2003). On the photometric diagrams on Figure 2 one can see that these stars form two subgroups: one at c_1 about 0.95 mag (very late B-type; all of them fainter than 9 mag; marked with plus symbols on all diagrams), and another at $c_1 = 0.55$ mag (all of them brighter than 9 mag and marked with crosses on all diagrams). This separation is also evident according to the Hβ index (Fig. 2c), which implies that the first subgroup (plus signs) is intrinsically fainter than the second (crosses) (Fig. 4). In terms of distance, they show a significant spread on the diagrams presented in Figure 3. Four of these stars (7243−490, 7243−480, 7243−380, 7243−370) are reported to be spectroscopic binaries (Hill & Barnes 1971), which can affect the photometric distance estimates. If we remove them from the sample, four faint stars (plus signs) remain, located between 800 and 1000 pc. The average distance of the stars closer than 800 pc is 678 ± 50(s.e.) pc, which is 80 pc shorter than the determination of Hill & Barnes (1971) but in good agreement with the result of Jilinski et al. (2003). Note that these distance determinations agree within the errors, which implies that the cluster stars could be significantly spread out over distance. However, the background group identified here could be due to intrinsic error of the data at faint magnitudes.

Hill & Barnes (1971) estimated a mean cluster radial velocity of -9.3 ± 1.0 km s^{-1}. The difference in distance and mean radial velocity does not suggest a connection between Lac OB1 and NGC 7243.

6. RESULTS FROM *HIPPARCOS*

The membership of stars in an OB association may also be based on the assumption of a common space motion of all members. The issue is, however, far from being trivial, as discussed by de Bruijne (1999). Figure 5 contains the vector point diagram $\mu_\alpha \cos\delta$, μ_δ for the program stars as obtained from the recalculated *Hipparcos* catalog, with their standard errors indicated. The general difference between the well defined concentration of the Lac OB1 association (including 10 Lac) and the rest of the stars in the field is evident. The *Hipparcos* proper motions support the existence of Lac OB1 as identified in the previous paragraph.

Nine of the 12 photometric members of the Lac OB1 group identified in the previous paragraph have been measured by *Hipparcos*. If we include 10 Lac, the recalculated parallaxes of these stars (van Leeuwen 2007) lead to an average estimate of 2.079 ± 0.191(s.e.) mas. This revised value is in good agreement with the average photometric parallax of 1.193 ± 0.172(s.e.) that can be obtained from the distances listed in Table 2. The median *Hipparcos* value of 1.99 mas for these stars is in even better agreement with the median photometric parallax of 1.88 mas. If we exclude 10 Lac from the comparisons, the difference between the average photometric parallax of 1.971 ± 0.168(s.e.) (518 pc) and the *Hipparcos* estimate 2.100 ± 0.191(s.e.) is less than 7%, completely within the expected

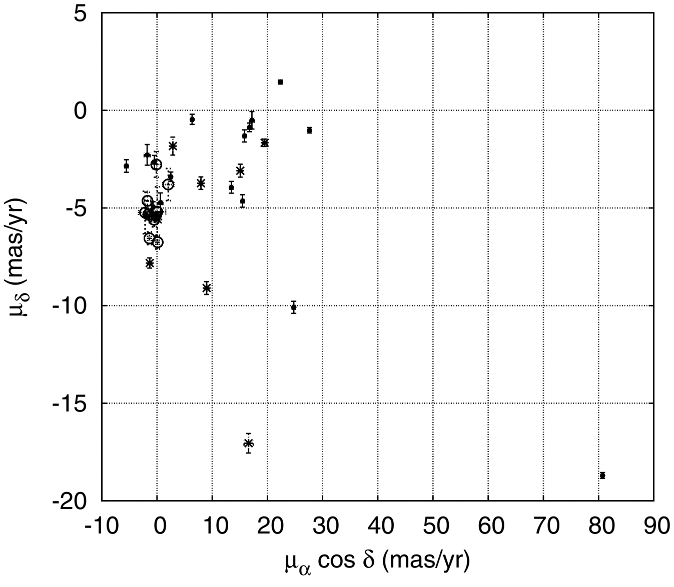

FIG. 5.—Proper motions inferred from the recalculated *Hipparcos* catalog, with the standard errors indicated. The same symbols as in Fig. 2 are used.

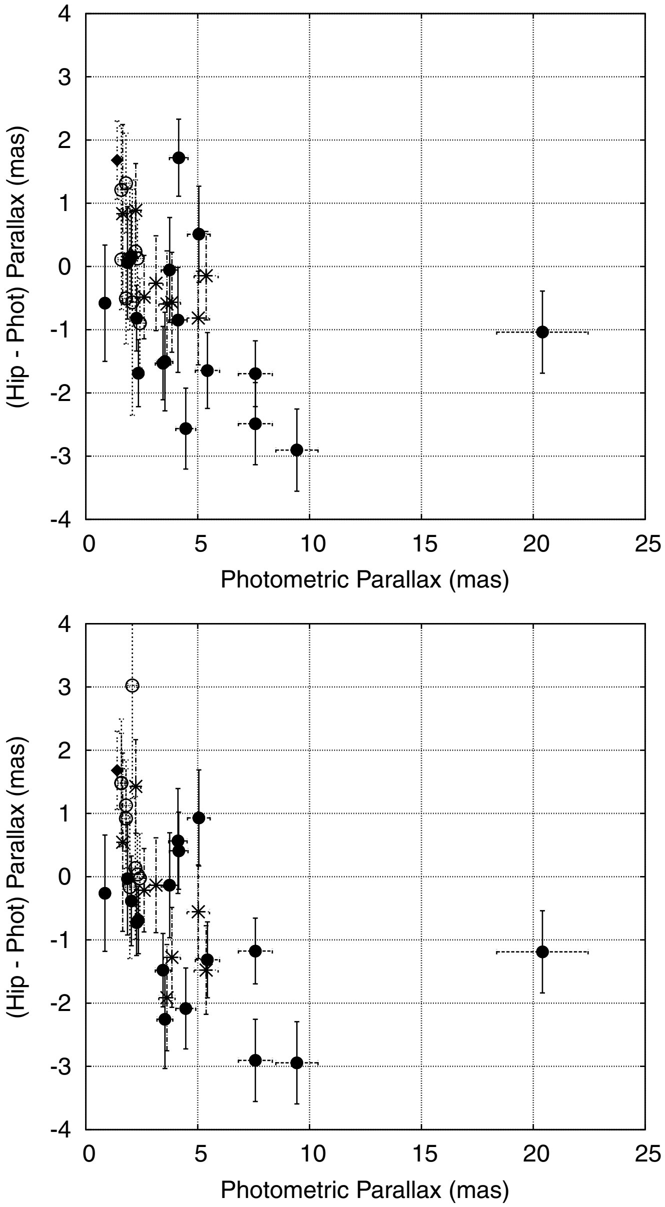

FIG. 6.—The comparison between the recalculated *Hipparcos* parallaxes and the photometric parallaxes (*top*) and the original *Hipparcos* parallaxes and the photometric parallaxes (*bottom*) for stars of the sample. The same symbols as in Fig. 2 are used.

errors, while the corresponding original *Hipparcos* parallax is 2.86 mas (350 pc, de Zeeuw et al. 1999). The agreement between the photometric and the recalculated *Hipparcos* parallaxes is evident for this group.

For the subgroup of 8 stars toward $l = 99.6°$, $b = -17.6°$ (asterisks) the average photometric parallax of $3.44 \pm 0.29(\text{s.e.})$ mas is in agreement with both the recalculated and original *Hipparcos* parallaxes of $3.29 \pm 0.37(\text{s.e.})$ mas and $3.50 \pm 0.39(\text{s.e.})$ mas respectively. For the field stars (filled symbols) however, the recalculated *Hipparcos* parallaxes are not much different from the original ones, leading to an average value of the difference between the recalculated *Hipparcos* and the photometric parallaxes of -0.99 ± 0.3 mas. A discrepancy of the same magnitude has already been reported for a number of clusters and associations (cf. Kaltcheva & Makarov 2007). Figure 6 presents the comparison between the recalculated and original *Hipparcos* data and the photometric parallaxes for the three subgroups discussed in the preceding paragraphs. A better agreement is evident when the recalculated parallaxes are used, but discrepancies remain for this particular field. Since it is not clear how the recalculation of the *Hipparcos* parallaxes would affect the membership of the Galactic OB associations provided by de Zeeuw et al. (1999), a revision of the previous *Hipparcos* distance estimate for the *Hipparcos* members selected by these authors was not attempted.

7. CONCLUSIONS

Precise homogeneous $uvby\beta$ stellar distances and reddening are derived for a sample of 55 stars earlier than A0 spectral type in the field of Lacerta. The recalculated *Hipparcos* parallaxes are used in conjunction with the photometric results to study the spatial distribution of the sample stars. The main findings of this investigation are as follows:

1. Lac OB1 is identified as a compact group of 12 low-reddened MS stars showing small spread in distance in the direction $l = 96.4°$, $b = -16.6°$. The group appears to be real, located at a distance 520 ± 20 pc. The recalculated *Hipparcos* parallaxes of nine of these stars (van Leeuwen 2007) provide a much better agreement with the photometric estimates than the original *Hipparcos* values. The available radial velocity and proper motion measurements indicate that the group is real. The photometry implies that the O9-type star 10 Lac is significantly more distant than the association Lac OB1.
2. The stars in the northeast part of the field do not form a physical group, but rather a layer between 140 and 400 pc, with some more distant stars toward $l \sim 104°$. For these stars a disagreement between the photometric and *Hipparcos* data is still present.
3. Based on the brightest members, an estimate of $678 \pm 50(\text{s.e.})$ pc is obtained for the distance to the open cluster NGC 7243.
4. Although a better agreement is now evident between the photometric distances and the recalculated *Hipparcos* parallaxes in comparison to the original *Hipparcos* data, discrepancies still seem to exist for this particular field.

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